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Washington, D. C. 20024

date: July 27, 1971

to: Distribution

B71 07046

from: I. Y. Bar-Itzhack

subject: LRV Navigation System Error Analysis for the Apollo 15 Traverses - Case 320

ABSTRACT

A digital simulation of the performance of the LRV Navigation System is described. The simulation used the specification gyro drift rate of 10°/h and the estimated misalignment error of 3%, evaluated over traverses that were being considered for Apollo 15 as of January 1971. The following results were obtained:

a. In order to keep the maximum Navigation System position error under 600 meters, the gyro has to be realigned only once during the first traverse, at the end of stop number 3.

b. For the second traverse, the same error criterion is met with three realignments at the end of stops number 5, 6, and 9.

c. Two realignments are necessary for the third traverse, at the end of stops number 12 and 14.

d. The effects of lunar rotation, lurain roughness and a slip of 1.85% are negligible in comparison with the effect of either 10°/h or 5°/h gyro drift and 3° misalignment errors.

Due to the last result a valid traverse analysis can be made accounting only for misalignment and gyro drift errors.

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MEMORANDUM FOR FILE

The Rover Navigation System Simulation Program described in Reference 1 was used to evaluate the expected maximum position errors in the LRV navigation system during the three Apollo 15 traverses.

The traverses that were simulated are shown in Figure 1. They are the update of January 28, 1971; however, since times and distances rather than the exact traverse geometry are the major factors in error generation, this analysis should be also valid for later traverse updates. They were reduced into segments of straight lines and arcs for input to the simulation program. The resultant traverses which were followed by the simulated rover as a result of these inputs are shown in Figure 2. The value used for the misalignment error was 3° and the maximum value used for the gyro drift rate was 10°/h. The first number was estimated in Reference 2 whereas the second number is the specification value (see p. 2-28 in Reference 3). Two classes of runs were made; in the first, the specification gyro drift rate of 10°/h was used, while in the second 5°/h was used because this is expected to be closer to actual drift rate of the system. The results of those runs are tabulated in Table I.

For each condition the traverse was run without any alignments and then re-run with an alignment added until the maximum error between the true LRV position and the position indicated by the navigation system was less than the specification value of 600 m (see Reference 3). The science stops for the alignments were selected on the basis of their duration (the longer stops accumulate more drift errors) and their distribution along the traverse. It can be seen from Table I that the effects of either 1.85% slip or lurain features were relatively small. (The value of 1.85% for the Apollo 15 estimated slip was given by MSFC.)

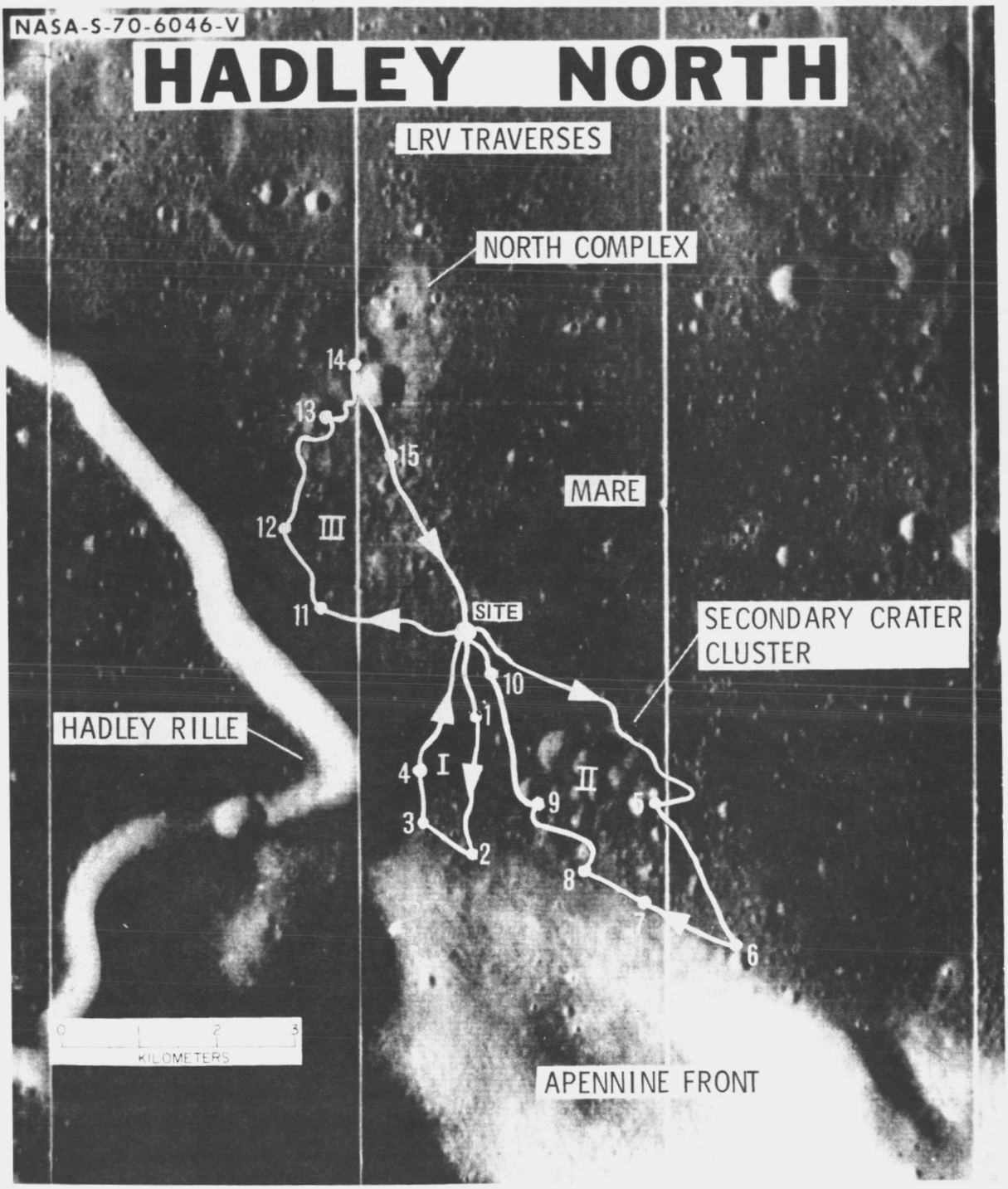

FIGURE 1 - APOLLO 15 TRAVERSES (1/28/71 REVISION)

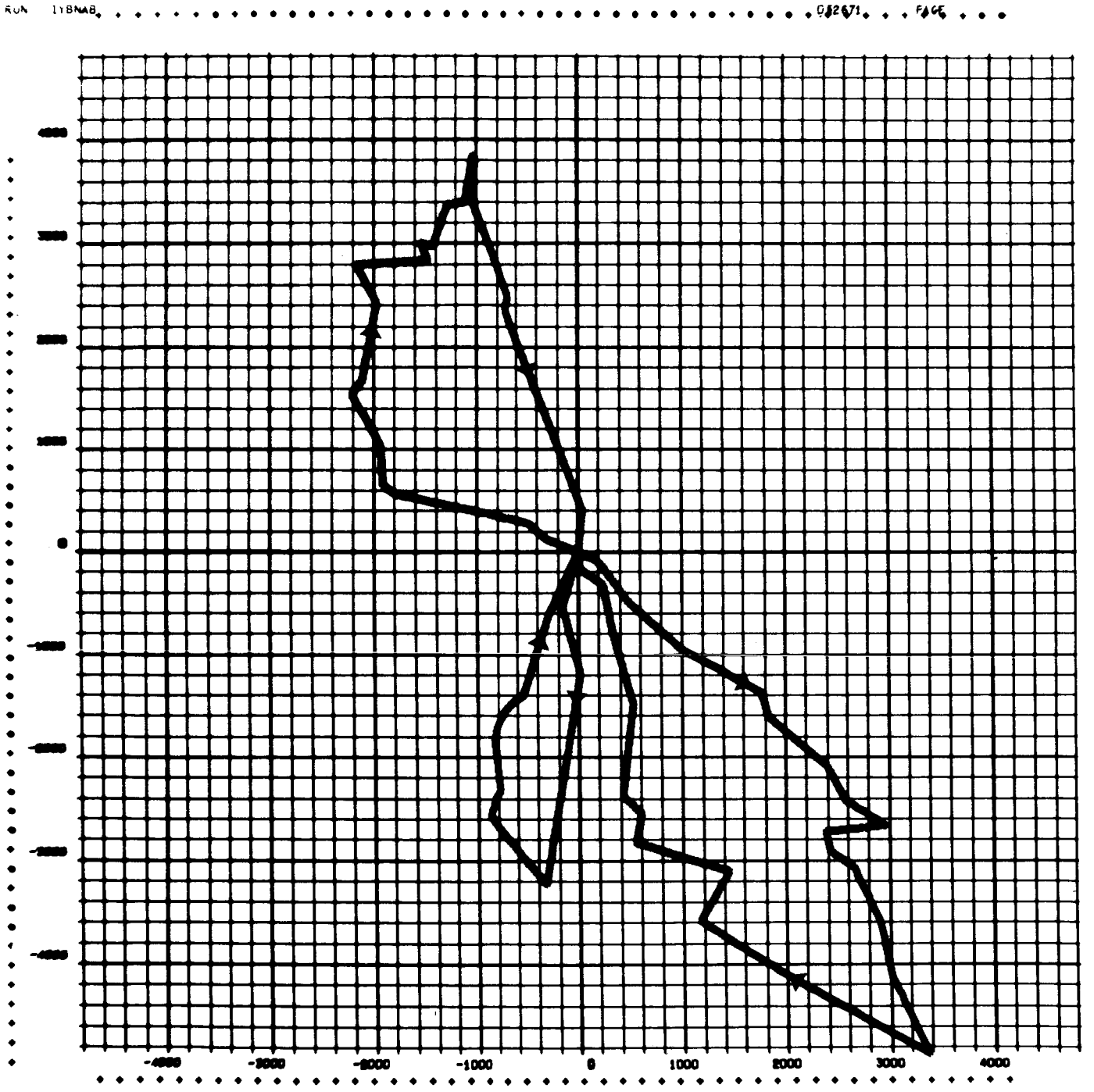

FIGURE 2 - A 4020 PLOT OF THE APOLLO 15 TRAVERSES AS FOLLOWED BY THE SIMULATED LRV

TABLE I

MAXIMUM LRV NAVIGATION ERRORS (IN METERS)

			10°/h DRIFT			5°/h DRIFT		
			WITHOUT LURAIN		WITH LURAIN	WITHOUT LURAIN		WITH LURAIN
TRAVERSE #	Nos OF ALIGNS	AT STOP #	NO SLIP	1.85% SLIP		NO SLIP	1.85 SLIP	
1	0	-	1070	1090	1082	528	538	535
	1	3	314	322	322	--	--	--
2	0	-	3132	3190	3183	1584	1613	1604
	1	6	994	995	987	641	646	641
	2	5,9	1114	1286	1144	552	562	567
	3	5,6,9	507	519	515	--	--	--
3	0	-	1845	1879	1875	939	957	960
	1	14	1076	1053	1054	630	610	611
	2	12,14	537	531	526	369	369	365

Note: Alignment error = 3°

From the results shown in Table I it is concluded that in order to keep the maximum position error under 600 meters in the worst case of 10°/h gyro drift it is necessary to realign the gyro once at the end of stop number 3 on the first traverse, three times at the end of stops number 5, 6, and 9 on the second traverse, and twice at the end of stops number 12 and 14 on the third traverse. It would appear that if the actual gyro drift rate is only 5°/h, one alignment could be eliminated from each traverse.

It is essential that the realignments be performed at the end of the stops since these stops are for relatively long durations and the gyro drift rates lead to a large heading error. The results of Table I agree closely with those given in Reference 4. Since it was found that lurain characteristics and slip are not necessary for a valid analysis, a simpler analysis of the traverses using only misalignment and gyro drift errors is adequate.

Itzhack Bar-Itzhack

2031-IYB-jf

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Attachment
References

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1. Bar-Itzhack, I. Y., "A Description of the Navigation Simulation Program", Bellcomm Memorandum for File, B71 07045, July 27, 1971.

2. Heffron, W. G. and LaPiana, F., "The Navigation System of the Lunar Roving Vehicle", Bellcomm Technical Memorandum, TM-70-2014-8, December 11, 1970.

3. "Lunar Roving Vehicle Critical Design Review - Afternoon Session", June 16, 1970.

4. LaPiana, F., "LRV Navigation System Realignment Requirements for the Apollo 15 Traverses as Revised January 28, 1971", Bellcomm Memorandum for File, B71 04045, April 22, 1971.

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